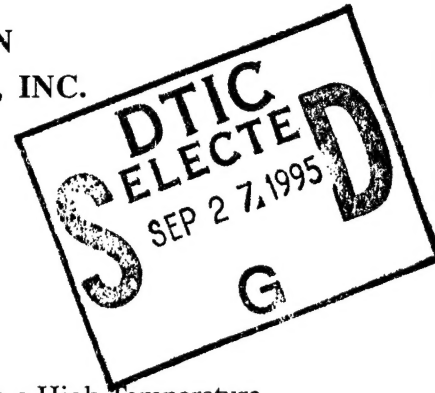


CONTRACT No. N00014-94-C-0210 BETWEEN
the OFFICE OF NAVAL RESEARCH and NEOCERA, INC.

FOURTH MONTHLY PROGRESS REPORT
dated January 23, 1995



1. Introduction

The goal of this SBIR Phase I project is to establish the feasibility of designing a High Temperature Superconductor (HTS) Superconducting QUantum Interference Device (SQUID) microscope in order to detect defects, and verify customizations and repairs in MCM substrates. The overall goal of this SBIR program is to market an HTS SQUID microscope dedicated to the inspection of MCM substrates in a manufacturing environment. Neocera and its subcontractor, the Center for Superconductivity Research at the University of Maryland, are working collaboratively in this effort.

Initial efforts focused on: demonstrating that a room temperature object can be brought sufficiently close to a cryogenically-cooled SQUID sensor to image electrical defects (shorts, opens, voids, particulate contamination, etc.); constructing a room temperature sample stage; and assembling the sensor control and readout electronics. Each of these subtasks have been accomplished.

The current effort is focused on assembling, testing, and debugging the prototype SQUID microscope, with a cryocooled sensor and a room temperature sample stage. During this period, the microscope was assembled. Upon cycling to cryogenic temperature, two issues were identified and solutions implemented: an inadequate thermal link, and a poor sensor epoxy bond.

2. Inadequate Thermal Link

The initial design of the thermal link proved inadequate. The link provides a thermal connection from the high- T_c SQUID sensor to the 77 K bath and consisted of a copper braid and a copper rod. In fact, the thermal conductance was so poor that it was not possible to cool the SQUID down to 150 K. Upon subsequent testing, it was found that the thermal load on the sample had been substantially underestimated, while the conductance of the link had been overestimated. The inadequate thermal link prevented the SQUID from operating since it must be cooled below about 88 K.

In order to resolve the problem, a new thermal link needed to be designed. The new design employs a copper tube connected to a stainless steel bellows which is in turn connected to the liquid nitrogen bath. The sapphire rod, on which the SQUID sensor is mounted, is epoxied into

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the end of the copper tube. The tube and bellows reside in the position of the old thermal link, leaving the SQUID position unchanged. When the dewar is filled with LN₂, the tube and bellows also fill up, providing direct contact between the sapphire rod on which the SQUID is mounted and the 77 K bath. To prevent the tip from shaking around, the tube is clamped to the outer jacket of the dewar using thermally insulated spacers, much as in the earlier design. The bellows are necessary in order to take up strain produced by thermal contraction when the dewar is cooled.

In preliminary tests on the new design (with the dewar vacuum space evacuated and the dewar filled with liquid nitrogen), it has been possible to cool a thermometer attached to the sapphire rod to 80 K. This indicates that the new design has a thermal conductance which is more than adequate and resolves the main difficulties encountered in the initial design. By moving the window close to the end of the rod, it has also been demonstrated that no significant amounts of moisture or ice condense on the window.

3. Sensor Epoxy Bond

A second issue was discovered after initial cooling of the first prototype assembly: the SQUID sensor chip had detached from the sapphire rod. Recall that the SQUID is deposited on a small chip of SrTiO₃ which is then epoxied to the end of a sapphire rod. The rod and chip are ground down, leaving the SQUID on a small point at the end of the rod. Examination of the epoxy on the end of the point revealed a very weak bond between the epoxy and the sapphire. After several "dunking" experiments, it was determined that inadequate mixing of the black Stycast starting material was likely the origin of the problem. With the epoxy thoroughly mixed, strong bonds were obtained which could withstand repeated thermal cycling and substantial mechanical pressure.

A new SQUID point was prepared with the additional step of roughening and thoroughly cleaning the mating surfaces. In addition, after the point was ground down and the electrical contacts made, some epoxy was used to coat the exposed edges of the chip and sapphire, giving the point an additional grip on the sample. The SQUID-point has been dip tested in LN₂, and the chip and contacts are working.

4. Plans for the Next Period

- Reassemble the SQUID microscope dewar and sensor subassemblies.
- Continue full testing of the prototype HTS SQUID microscope.
- Obtain reject/damaged actual MCM for imaging tests.

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